Renewable and Sustainable Energy Reviews 13 (2009) 2419–2429

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Creation of regional added value by regional bioenergy resources

Dunja Hoffmann *

German agency for technical cooperation (gtz), Dag-Hammarskjöld-Weg 1-5, 65760 Eschborn, Germany

ARTICLE INFO

Article history:
Received 19 December 2008
Accepted 16 April 2009

Keywords:
Regional added value
Renewable energy
Biomass
Bioenergy
Indicator
Tool
Sustainable development
Project impact

ABSTRACT

In debates about the positive effects of renewable and bioenergy projects the aspect of generating regional added value is discussed widely. But the real effects, generated by this regional added value stayed up to now on a non-measurable level. In order to expedite the calculation of these important figures, the author presents a field tested method for confidently arriving at useful values. This methodology takes into consideration the ecological, economical and social impact of a given biomass project's implementation. The model enables a comparison between the different renewable energy plants as well as between them and plants and technology of competing alternatives. Regional authorities are hereby enabled to count on a tool for confidently measuring the possible results of various bioenergy utilization technologies. With this knowledge at hand, they could then take qualified decisions towards positive effects for their region. The developed tool allows the definition of adjustable parameters, and therefore it is able to influence the regional framework regarding a more sustainable development.

Contents

* Tel.: +49 6196 79 1374; fax: +49 6196 79 80 1374.
E-mail address: hoffmanndunja@web.de.

1364-0321/$ – see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2009.04.001

1. Introduction

A sustainable regional development aims to utilize endogenous resources as long as they meet the requirements of sustainability. Many of these resources are used inefficiently or are not used at all. These include, but are not limited to, renewable energy sources and the knowledge for their utilization. Bioenergy offers a viable alternative for regional energy production and should therefore be considered to improve regional development.

Besides economic reasons for implementing a project, there can also be other main aims to be targeted, such as environmental protection or the generation of regional added value. In debates about the positive effects of bioenergy projects this last aspect is discussed widely. The effects of regional added value stayed up to now on a non-measurable level. The causes were mostly inconsistent definitions and the lack of a model or tool, able to calculate the results of implementing bioenergy projects in a region.

In order to expedite the calculation of these important figures, a field tested method for confidently arriving at useful values is required, considering the ecological, economical and social impact of a given biomass project's implementation.

2. Regional added value

The term "regional added value" is being utilized more and more in the discussion about implementation of renewable energy and other projects that intent to support regional/decentralized development for showing an additional benefit apart from classical economic benefits for the companies implementing the projects. But, taking a closer look at the definition and the utilization of the term, a lack on measurable methodologies to define the value and its results that might be created by different measures is obvious. Therefore, this work is focusing on defining the meaning of the term in the context of the article and adjacent shows a methodology to develop a measuring system for different projects and alternatives that can cause the described effects and can be therefore compared to each other.

A value is defined as a subjective use for one person. Values are used to fulfill desires and therefore are subjective, based on the definition that a benefit for a person is defined as the achieved satisfaction of a need or desire. The instruments to fulfill these desires are either free or have to be generated (compare [1–3]).

The generation of values therefore consists in the generation of uses for a person or a group of people. These values contain material and immaterial goods. This definition displays the problem of comparability of different values. While economic values can be measured easily; the measurement of ecologic and social values presents a problem. Therefore, in general the term is mostly used in the economic framework where creation of value is mostly used to describe the production of values for customers as products or services where the price paid by the customer is indicating the value [4]. From economic point of view the reduction of the term on purely economic factors is reasonable. In choosing a broader area of investigation, considering its possibilities for development, supported by defined measures that cause regional and national interrelations, non-monetary effects are getting more important and cannot be neglected.

For traducing the term "added value" to a region Heck [5,6] provides an approach in defining regional added value as "the sum of all additional values (...) that are being produced in a certain time". In this context the monetary aspects as well other effects like reduction of cost, increase of purchasing power, new created employment, higher tax income as well as social, ethical and ecological aspects have to be considered [5].

This definition requires a specification of the different long-term results of the measures that generate values. While the utilization of sustainable produced renewable energy contributes positively to the development of society, exploration and utilization of fossil resources on the other hand generate also revenues and benefits but the use of these goods tends to have negative influence on society and ecology on a long-term base. Examples for this can be effects of climate change, effects of dependency from foreign countries and negative effects on natural capital. This can cause loses in welfare which will reduce values and generate values that cannot be considered to be positive from society point of view. Therefore, positive and negative effects of each project have to be considered and compared (if responsibility can be located).

Sustainable regional added value in the framework of this work is therefore defined as the sustainable generation of a benefit that bases on the generation of values after reducing the non-sustainable or negative values by regional projects.

3. Methodology

The methodology used to develop the tool is based on an on site analysis that allows the adaptation of the mechanism to different regional situations, backgrounds and preferences. This document describes the different steps to be done for creating a system to analyze the regional added value of different systems and allows them to be compared under the given preferences. It includes the analysis of the actual situation on which the new project to be compared will be implemented, as well as the analysis of the potential for future projects of the same type and its impacts. It also defines necessities of investment for implementation. To enable a comparison of the different results the term "value factors" is introduced, that helps to specify and classify different effects in the economic, ecologic and social areas which can be compared by feeding them to a specially developed indicator system that allows the evaluation of the project in comparison to others. After introducing the system, suggestions for the generation of the required data are made. The paper gives an example of required data for the execution of a regional added value analysis. With help of the obtained data, results can be compared and future projects can be optimized by well directed planning.

4. Development of a regional added value analysis

The methodology for the analysis of regional added value is part of the work developed by the author [7] in different regional bioenergy projects in Rhineland-Palatinate/Germany. It aims to offer a methodological support for project developers and decision makers in the area of renewable energies to develop their own criteria of evaluation that can be integrated in the proposed method.

4.1. Background and presumptions

A large part of the consumed energy in countries without relevant own energy resourses nowadays comes from imported fossil fuels. This also means that money which is leaving the country for energy consumption cannot be spent for buying goods and services inside the country or region. With rising energy prices the region therefore gets poorer every year even if energy consumption can be kept stable. The idea of generating regional added value by using regional biomass therefore includes enabling the regional market participants to spend money for the same service (e.g. a warm house or electricity for industrial use), within the region and to analyze and monitor the effects generated by different projects in this field. Obviously there will be different

effects by implementing different technology using the same potentials, e.g. organic residues or agricultural area available for cultivation of energy crops. The following methodology therefore allows evaluating these effects and allows comparing different projects or alternatives that can be implemented using the existing potentials for producing bioenergy.

4.2. Analysis of regional energy consumption

As a first measure in the process to analyze the effects of regional added value by implementing regional bioenergy potentials, the actual sources for energy supply have to be documented. The analysis includes a registration of the primary energy consumption and its fossil and renewable generation sources, mentioning their regional and non-regional shares. Further more data about end energy use (electricity, mineral oil, coal, etc.) in the different sectors (industry, transportation and private households) are necessary for defining different cost structures. This data can often be received from energy balances elaborated by the governments for different regions. In case that the primary energy consumption does not exist it can be estimated by adding the "cumulated energy effort" to generate the final energy containing unit (e.g. electricity) which includes all the energetic effort for its generation (see Table 1).

After defining the amount and percentage of imported primary energy the costs of production of each unit for importation and therefore the loss of liquid money in the region can be defined. To simulate future development different percentages of augmenting prices can be assumed on base of these data. If a region (of approximately 4 Mio. habitants) imports 98% of its primary energy consumption of 500,000 TJ and produces only 2% of own renewable resources and structure and costs of energy consumption is known (e.g. 18.00 EUR/GJ as a combined price of gas, gasoline, electricity in dependence of their use in the analyzed year) a yearly flow of 8.820 Mio. € is leaving the region for energy consumption. Assuming a 2% price increase per year, in 6 years the amount of more than 10,000 Mio. €/a is leaving the region for energy consumption. If instead a part of this money can be kept in the region for regional energy projects that are themselves generating turnover and benefits in regional companies, a "multiplication effect" can be generated that supports regional economic development and can also have positive effects on social and ecological issues.

4.3. Analysis of potentials for bioenergy production in the region

As a baseline for a possible outcome of a strategic implementation of a regional bioenergy concept, the regional available bioenergy potentials have to be evaluated. Talking about potentials, there is a wide variety of definitions being used in the literature and practice. To clarify the possible outcome and its real feasibility it is important to have explicit definitions of the terms of potentials applied to the concept. There can be different levels of potentials distinguished, depending on their feasibility. Theoretical potentials are defined as the maximum of the biomass to be available for which a technical utilization is possible (Fig. 1). These potentials can also be defined as the primary energetic potential. It does not include loses of recuperation of harvesting.

The technical/ecological potential is the amount of the theoretical potential that can be technically processed to an energy source, considering existing laws and the principals of sustainability. Loses of recuperation and harvesting are already considered. Ecological potentials are therefore included in the technical potentials.

Economic potentials are the ones to be implemented if their users expect an economic benefit in their implementation. These potential is influenced by assumptions for economic investment, by political and economic framework and subsidies as well as by the expected prices for substitutes. Therefore, economic potentials are depending on time and space and as well on preferences of market participants. Assuming an optimized development on behalf of bioenergy utilization, economic potentials can be approaching technical potentials.

Table 1
Example for the cumulated energy effort of different energy carriers [8].

Energy type	Process[a]	Cumulated energy effort (kWhprim/kwh end)			Greenhouse gases
		Total	Non-regenerative part	Regenerative part[b]	CO_2-equivalent (g/kWh end)
Fuels[c]	Mineral heating oil EL	1.13	1.13	0	311
	Natural gas	1.14	1.14	0	247
	Liquid gas	1.13	1.13	0	272
	Coal	1.08	1.08	0	439
	Brown coal	1.21	1.21	0	452
	Wood chips	1.07	0.05	1.01	35
	Firewood	1.01	0.01	1	6
	Wood pellets	1.16	0.14	1.03	43
Electricity	Electricity mix	2.98	2.68	0.3	683
	Electric heating mix	2.91	2.91	0	930
	Electric heating on coal base	2.69	2.69	0	1034
	Photovoltaic electricity (near consumer)	1.84	0.74	1.1	248
	Wind energy (coast and inland)	1.04	0.03	1	20
Long distant district heating[d]	Long distance district heating 70% CHP	0.78	0.77	0.01	241
	Long distance district heating 35% CHP	1.13	1.12	0.01	323
	Long distance district heating 0% CHP	1.49	1.48	0.01	406
Short distance district heating[d]	Short distance district heating 70% CHP	0.73	0.72	0.01	−70
	Short distance district heating 35% CHP	1.11	1.1	0.01	127
	Short distance district heating 0% CHP	1.48	1.47	0.01	323

Long distance district heating by coal condensation plant (=percentage CHP) + oil kettle for piek generation. Short distance district heating by natural bas CHP (=percentage CHP) + natural gas kettle for piek generation.
[a] Pre-chain for end energy until delivery in building, incl. material costs for heat generator, without auxiliary materials in the house.
[b] The regenerative part also includes secondary recourses, e.g. rest wood and waste.
[c] Reference parameter: lower fuel value H_u.
[d] Electricity credit for electricity from coal.

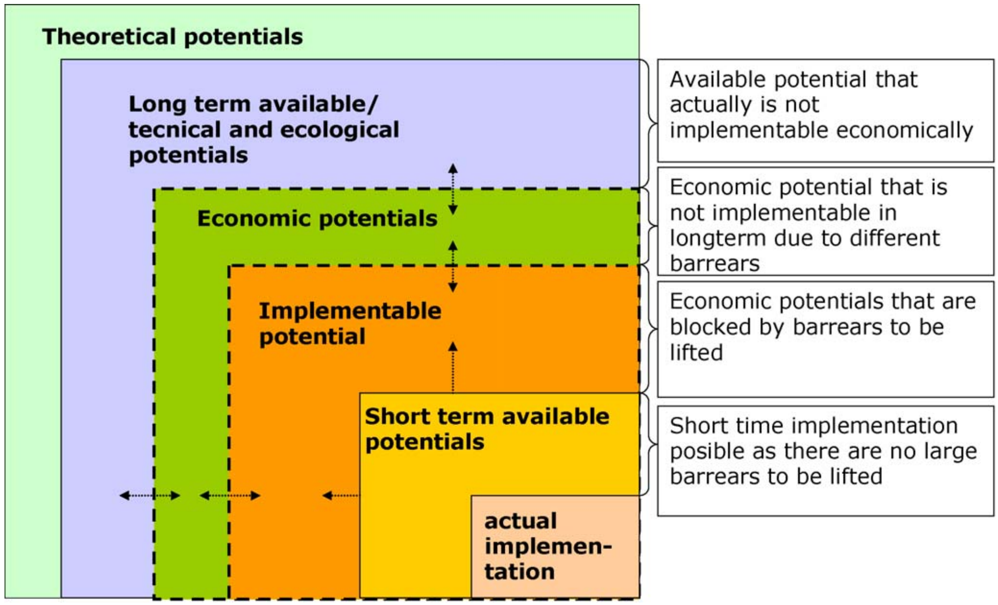

Fig. 1. Potential categories [7].

Long-term available potentials are economic potentials available for implementation considering non-monetary and non-technical restrictions. For their full implementation structures have to be optimized, actual disposal ways and non-optimized law framework as well as reduction of non-monetary hazards (information, communication and qualification lacks) have to be considered.

Short-term available potentials are part of the economic potentials and define the quantity of biomass to be activated for bioenergy use during approximately 1 year while considering economic and political frameworks as well as actual habits of utilization of the biomass. It can be defined as a "starting capital" that can lead to a faster implementation of the first projects and to an establishment of structures favorable for bioenergy projects.

After defining the potential levels the available biomass for each category can be defined, mentioning the energy content in MWh or GJ. As a starting potential the short-term available biomass can be considered for the calculation. For future perspectives long-term potentials can be included to simulate the change of results.

Because of the different effects of the implementation of different biomass technology to be used for different input material it is necessary to divide the biomass potential into material groups (woody material, fermentable material, oil containing liquid biomasses and other biomass to be burned, see Table 2).

For each category of biomass their mayor substitute product has to be defined. If based on the regional economic and political conditions vegetable oil is mostly substituting diesel as a fossil fuel, the price and emissions factor of this fuel can be considered to be replaced by the bioenergy, whereas fermentable bioenergy in Germany is mostly transformed into electricity and heat which means that a substitution of approximately 33% of the bioenergy potential can be considered as electricity not having to be produced by fossil fuels and 66% of heat not produced by mineral oil or gas. Table 3 shows an example of the potentials of reduction by substituting fossil fuels by regional renewable bioenergy potentials.

By comparing the analyzed potentials to the amount and prices of the energy they substitute, the reduced loses of funds for only energy consumption formerly imported into the region can be calculated and the amount of money newly available for implementing regional bioenergy projects can be defined. After reducing the effects of substitution of regional structures for fossil fuel supply the calculation shows the basic capital available for bioenergy projects. Therefore, each € not spent on imported fossil fuels, and instead spent on a regional bioenergy project can have a multiple effect on structures in the region.

4.4. Definition of the needed investment for implementing renewable energy in comparison with the reduced loss of financial funds

Once the reduced loses of funds are calculated as described in the former steps, the requirements for implementing bioenergy projects on base of these funds have to be defined. Because of the necessity of implementing and investing into new technology it is not enough to only calculate the costs of production. Also the costs and effects of investing in renewable energy technology to enable the energy production in the region based on regional potentials have to be considered. In comparison with energy production from fossil fuels bioenergy projects have a different cost and supply structure. Therefore, the funds will have to be divided into different areas. Investment, planning and personal cost for the operation of bioenergy projects are usually higher than for fossil energy projects,

Table 2
Potential total for bioenergy utilization in Rhineland-Palatinate [9].

Potential total of Rhineland-Palatinate in groups of	Theoretical in MWh		Technical in MWh		Available in MWh	
	Min	Max	Min	Max	Min	Max
Woody biomass	15,325,365	15,634,772	11,484,910	11,728,847	4,213,294	5,245,998
Other combustibles	6,590,732	6,590,732	5,222,600	5,222,600	932,796	932,796
Fermentable biomass	11,619,654	13,064,240	8,166,252	9,064,726	1,030,376	1,629,180
Oily biomass	1,597,149	1,597,149	1,286,931	11,286,931	503,372	503,372
Sum	35,132,900	36,886,893	26,160,693	27,303,104	6,679,838	8,311,346

Table 3
Savings potentials of financial flows in compensation fossil energy by short-term available potentials in Rhineland-Palatinate [7].

Short-term available potentials in Rhineland-Palatinate	Input in	Compensation for	Percentage of production of respective end energy in % (no coefficient of effectivity)	Available potential in GWh before plant	End energy in GWh	Price in €/GWh for compensated energy container (actual)	Price in €/GWh for compensated energy container (with increased prices)	Savings in € with implementing of potentials in the area private households, small users and transport fuels	Savings in Mio€/a (actual)	Savings in Mio €/a (with increased prices)
Oily biomass	Diesel-motors	Diesel	100	503	503	92,000	112,147	46,276,000	46	56
Fermentable biomass	Biogas plants	Electricity	33	1030	340	170,900	208,326	58,088,910	58	71
		Mineral oil	66	1030	680	37,640	45,883	25,587,672	26	31
Other combustible biomass	Combustion	Mineral oil	100	933	933	37,640	45,886	35,118,120	35	43
Woody biomass	40% in CHP	Electricity	33	1685	556	170,900	208,326	95,040,224	95	116
		Mineral oil	66	1685	1112	37,640	45,883	41,864,412	42	51
Woody biomass	60 % in CHP	Mineral oil	100	2528	2528	37,640	45,883	95,154,793	95	116
Sum					6652			397,130,131	397	484

while costs for raw materials and transportation are mostly lower than for fossil energy production. Additionally, there can be revenues in terms of waste fees and – in case of certification – revenues from CO_2-certificates for greenhouse gas reduction from renewable energy projects. Basing on the condition that – from economical point of view – new projects are only executed if an economic benefit from their results can be expected, an additional benefit in terms of saved costs or earned benefits can be considered from regional projects. Fig. 2 describes the different areas and effects that can be caused by implementing a budget from money not spent for imported fossil energy but for regional bioenergy projects.

The utilization of renewable energy can have different effects on regional development:

- Savings by reduced costs of energy supply or earnings by operation of the plant (freeing capital).
- Turnover by buying regional fuels.
- Employment on the plant and in delivery and conditioning.
- (Higher) turnover in the region by (higher) investment.

To receive results concerning the economic added value the mentioned aspects have to be analyzed for different bioenergy technologies. Apart from the pure economic aspects, social and ecologic aspects are also to be considered to add to the value of the project. Mostly these aspects are less measurable or cannot be compared to the monetary effects.

4.5. Development of "value factors"

The so-called value factors were developed to facilitate the consideration of the different effects of different bioenergy plants already operating in a region or to be established in a region by future projects. These plants can be analyzed considering their results for the generation of "values" as an influence on the region. To analyze the different effects in closer detail, different criteria for the economic, ecologic and social area were developed. While economic values are often considered to represent the most important part for the generation of values, social and ecological values are also compared if measurable.

4.5.1. Economic value factors

4.5.1.1. Effects generated by investing in bioenergy technology. The fact that investing in a technology means binding financial capital implies that the same capital cannot be used for another purpose. Therefore, a profit-oriented investor has to decide which investment will bring the highest benefits. The revenues generated by the plant can therefore be used as basis for calculation of return of investment. But there can also be investment that does not generate revenues but costs for a required service (e.g. the production of heat). In this case the amount of the yearly or monthly costs is the relevant factor for calculation of profitability of the investment. Apart from the initial investment, operating a plant is also producing costs for operation, maintenance, personal and the yearly part of capital costs. During the operation time of the plant all these costs will have an effect on the region in which the plant is installed and will not occur in regions where this investment has not been implemented. Therefore, regional investment and their results can be noted as positive, as long as they are not in contrast to sustainability. Form and strength of the effects depend in each case on the characteristics of the investment. Each investment has therefore to be analyzed. Especially the components bought in the region are essential for the added value, because these parts generate work in pre-chains. On behalf of these chains other regional actors can participate in production, covering personal costs and gain benefits that afterwards allow them to spend the gained money in other (regional or

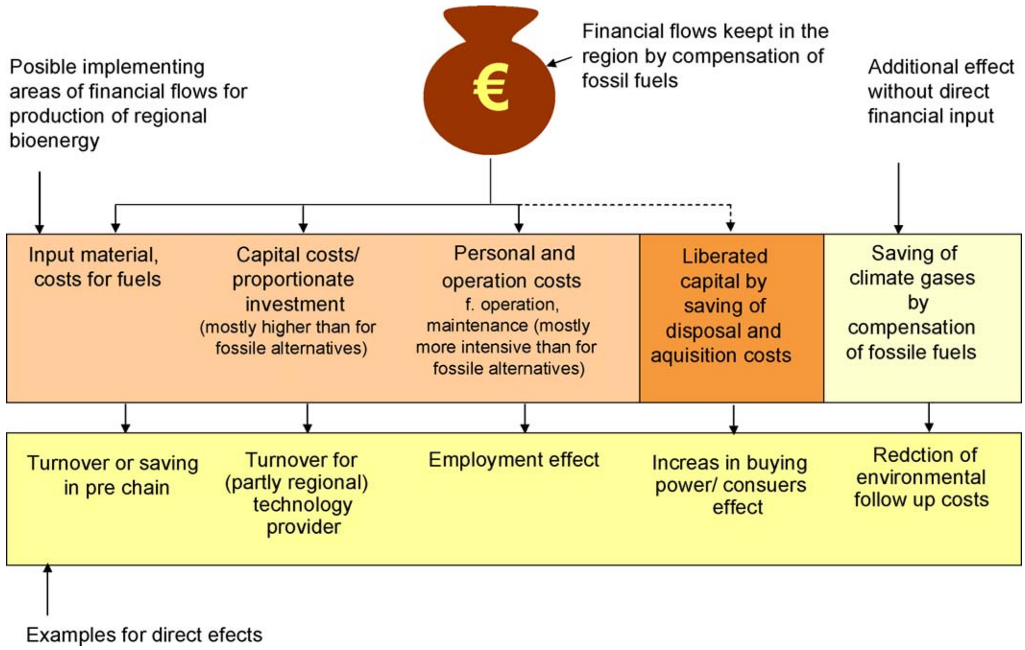

Fig. 2. Possible areas and effects for a budget not leaving the region for importing fossil energy while implementation of regional energy generation from endogen potentials [7].

non-regional) projects or products. An important factor – specifically for decentralized regions – is the effect of securing employment. Therefore, the following aspects are to be considered when analyzing investment costs:

- Amount of investment for establishment of the plant (including planning costs, parts, montage, permissions, etc.).
- Part of the investment coming from the region and from outside.
- If the plant is installed (a) instead of another/fossil/not energy generating plant (substitution investment) or if decision for investment (b) was taken on the base of expected benefits to be generated by existing input material (additional investment).
- In case (a) (e.g. for wood chip heating systems or waste treatment systems) the comparable costs for the alternative are to be analyzed. In this case only the difference between the two alternatives can be considered.
- In case (b) (e.g. for agricultural biogas plants or oil presses) the total investment is to be considered. In this case it is assumed that the investors would have deposited the part of their equity on average interest rate, if no other investment alternative is known.
- If there are fossil parts of the plant to be considered it has to be analyzed if they are essential for the operation of the plant or if they are additional and are not effecting the operation of the renewable energy plant. Fossil parts that cannot be substituted (e.g. pilot injection motor on small biogas plants) can be considered as part of the investment while additional parts are not to be considered.
- As a result of the investment the turnover by planning and constructing the plant in the different areas can be considered.

4.5.1.2. Results of operation of bioenergy plants. The operation of a plant generates a yearly turnover in the form of buying of raw material, consumables and selling of products and sub-products as well as generation of financial benefits, rents that can be generated by regional or non-regional market participants. In dependence of their origin and the form of operation the respective effects on the region are defined. For a regional point of view especially the origin of input material and the expenses (salaries, materials, interests, etc.) are important and have to be analyzed. If input materials have an alternative market the respective amount has to be reduced from the added value generated by the project.

4.5.1.3. Results of supply of bioenergy. The amount of biomass supplied to a plant generates revenue in the pre-chain. Therefore, the following aspects have to be analyzed:

- Costs and selling prices for supplying material flows, differentiated in material, personal and other costs and benefits.
- Origin of the materials and components obtained in the region.
- Significance of the price of the product for the seller (main product, sub-product or residue).
- Possibilities to activate additional – up to date not used – potentials and price differences between the former value and the value after activation.
- Alternative prices and channels of distribution for the product.
- Definition of the minimal amount of distribution for the provider to offer the service; definition of amount of product that releases additional investment.
- Analysis if and to which amount additional transportation costs can be saved.

4.5.1.4. Results of selling products from bioenergy plants. In dependency of the products the following aspects have to be analyzed:

- Prices to which the products are bought.
- Reduction or saving potential by preventing acquisition of alternative products.
- Possibility to generate other advantages by buying the product (e.g. higher value of fertilizers).

4.5.1.5. Levels of economic added value. Economic effects can be generated directly on the plant but also in previous areas when raw materials are bought in the region. Therefore, the effects of an investment can occur on different levels where the first level is considered to be the investing of the bioenergy technology. The key point from regional point of view is to define as much regional investment as possible. The second level is considering the revenues that reach regional market participants as a result of the activities in the first level. These revenues can generate products and services

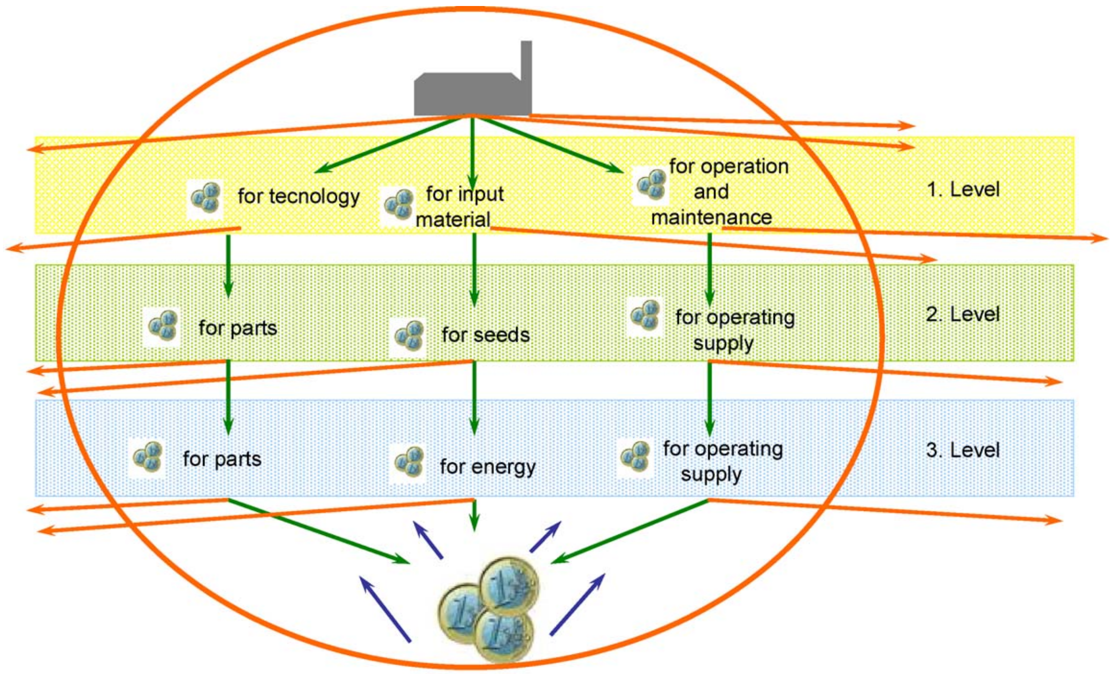

Fig. 3. Levels of regional financial flows [7].

themselves within or outside the region. As soon as the market participant is buying products or services from outside of the region the circle of regional financial flows gets interrupted. In case that market participants buy regional products further levels of regional participation can be generated. Fig. 3 shows different possible levels of effects to be generated. The longer the financial flows are kept in the region, the higher the possibility that original actors are able to participate on the added value.

The different levels are not limited to the fabrication of one product or plant but can have effects on all products and services in the region. In this work the emphasis lies on the first and second level, to demonstrate the effects generated by the investment and the possibilities of consequences for the region resulting from them. Generation of consciousness for the possibility of activation of these circles cannot activate bioenergy use solitarily but it can contribute to regional development by showing possibilities from utilization of regional recourses and can show a way to activate these recourses as a benefit for the region.

4.5.2. Social value factors

The social value factors are specifically important for the future sustainable development of a region. Educational opportunities and possibilities of integration of local people in new and existing companies generating values are granting future activities and financial incomes for the region. Therefore, generating and sustaining employment and additional qualification of regional staff is the main focus of the social value factors. In case that jobs in an area are reduced while others are established by the project, the reduced ones have to be considered in the generation of the values. Secured positions can be calculated in the same way as newly established ones because otherwise costs for unemployment would have to be financed by community (in case of governmental security for unemployment).

Specifically in the area of planning and clustering of plant supply, it is important to establish communication between possible partners and to generate networks between them to enable a more efficient use of synergy effects and existing information. Market participants already integrated in different networks can work as multiplier to facilitate the integration of new partners. For further development of new technology positive as negative examples, communication between the market participants and visiting different project sites are important factors. Considering this, the number of jobs and the number of people participating in the project is of high relevance. Therefore, the following aspects have to be considered in analyzing social value factors:

- Number of generated, secured and reduced jobs.
- Respective quality requirement of the employees for the jobs (high qualified, qualified, auxiliary/low qualified).
- Number of qualified people in the project.
- Number of groups of participants in the project.
- To what extent experienced personal or existing networks could be included in the project.
- Which roles played existing plants for the implementation of the respective plant (visits, percentage of possible implementation in comparison of the visits, results of the visits).

4.5.3. Ecological value factors

The ecologic value factors complement the formerly mentioned factors by the aspect of the analysis of future safety of ecologic factors. Positive and sustainable values can only be generated if the used recourses are available in long term. This can be measured by reducing CO_2-equivalent or other contaminant emissions like nitrate or malodor as well as ground erosion. The factors are compared to the alternative scenario that would have occurred without the project. The following aspects are therefore to be analyzed:

- If terms of sustainability concerning future availability of raw materials have been considered.
- Required area in m^2, separated in sealed and unsealed area used by the project.
- Additional area covered all year by plants and hereby generated grade of erosion reduction.
- Reduced amount of climate gases (CO_2, methane, etc. in CO_2-equivalent).
- Potential reduction of nitrate leakage.
- Potential reduction of malodors.
- Changes in biodiversity and danger of creating monocultures.

4.6. Development of indicators

Basing on the developed value factors in each category there will be resulting values (e.g. 100 t of CO_2-equivalent, 5 new jobs, 1 Mio € investment). To compare these values, indicators have to be developed to ratio the different effects of the different projects. Indicators are to be chosen in dependence of interest in the value added chain of the person or group analyzing the case (e.g. municipality, company, private person).

4.6.1. Economic indicators

General indicators for all plants:

- Total investment/unit input.
- Regional turnover (yearly regional accrual of funds)/€ total investment.
- Regional investment (regional accrual of funds once)/unit input.
- National investment/unit input.
- Average revenue/unit total input (material flows).
- Regional raw material costs (regional accrual for raw material)/unit regional input.
- Regional turnover (yearly regional accrual)/unit input (material flows).
- Regional turnover (yearly regional accrual) from raw material/unit regional input (material flows).
- Regional total accrual in €/€ alternative total export of financial funds for external energy acquisition.
- Total investment in €/€ alternative total export of financial funds for external energy acquisition.

Energy generating plants

- Total investment/kW_{el}.
- Regional investment/kW_{el}.
- Total investment/kW_{th}.
- Regional investment/kW_{th}.
- Regional turnover (yearly regional accrual)/kW_{th}.
- Regional turnover (yearly regional accrual)/kW_{el}.
- Regional turnover (yearly regional accrual)/MWh yearly input.
- Regional costs for treatment of residues/MWh_{el} in case of organic residues.
- Regional costs for treatment of residues/MWh_{th} in case of organic residues.

Transportation/treatment/drying

- Regional treatment costs/unit end product.

Consumer

- Acquisition costs/unit heat.
- Acquisition costs/unit electricity.
- Acquisition costs/unit product.
- Alternative acquisition costs/unit heat.
- Alternative acquisition costs/unit electricity.
- Alternative acquisition costs/unit product.
- Savings/unit heat.
- Savings/unit electricity.
- Savings/unit product.

4.6.2. Social indicators

General indicators for all plants

- Generated jobs/unit input.
- Generated regional jobs/unit input.
- Additional generated and preserved jobs/unit input.
- Reserved regional jobs/unit input.
- Displaced regional jobs/unit input.
- Total deployment/unit input.
- Placement of regional personal/unit input.
- Placement of high qualified regional personal/unit input.
- Placement of regional personal qualified in the project/unit input.
- Placement of low qualified regional personal/unit input.
- Capacitated personal/unit input.
- Additional generated and preserved jobs/unit regional input.
- Additional generated and preserved jobs/unit alternatively externally purchased energy.

Energy generating plants based on electricity production

- Additional generated and preserved jobs/kW_{el} installed.
- Displaced jobs/kW_{el} installed.
- Displaced regional jobs/kW_{el} installed.
- Total deployment/kW_{el} installed.
- Total deployment/kW_{th} installed.
- Placement of regional personal/kW_{el} installed.
- Placement of high qualified regional personal/kW_{el} installed.
- Placement of qualified regional personal/kW_{el} installed.
- Placement of low qualified regional personal/kW_{el} installed.
- Capacitated personal/kW_{el} installed.

Energy generating plants based on heat production

- Additional generated and preserved jobs/kW_{th} installed.
- Displaced jobs/kW_{th} installed.
- Displaced regional jobs/kW_{th} installed.
- Total deployment/kW_{th} installed.
- Placement of regional personal/kW_{th} installed.
- Placement of high qualified regional personal/kW_{th} installed.
- Placement of qualified regional personal/kW_{th} installed.
- Placement of low qualified regional personal/kW_{th} installed.
- Capacitated personal/kW_{th} installed.
- Supplied heat consumers/100 kW_{th} installed.

4.6.3. Ecologic indicators

Agricultural production

- Area required/unit raw material input.
- Additional or all year area cultivated in ha/unit raw material input.
- Reduced t CO_2-equivalent by substitution of mineral fertilizer/unit energy input.
- Reduced t CO_2-equivalent by substitution of mineral fertilizer/unit raw material input.

Energy generating plants based on electricity production

- Reduced t CO_2-equivalent/kW_{el}.
- Reduced t CO_2-equivalent/kW_{th}.
- Reduced t CO_2-equivalent by heat/unit raw material input.
- Reduced t CO_2-equivalent by electricity/unit raw material input.
- Reduced t CO_2-equivalent by electricity/unit energy input during lifetime of the plant.

Energy generating plants based on heat production

- Reduced t CO_2-equivalent/kWh_{th}.
- Reduced t CO_2-equivalent/unit raw material input.
- Reduced t CO_2-equivalent by heat/unit energy input during lifetime of the plant.

4.7. Evaluation of the indicators

The effort to raise these indicators depends on the market participant and its position in the value chain. The above-mentioned list gives therefore examples for generating a comparison that can be

extended or shortened in dependence of the technology to be analyzed. The significance of the results depends on reliability of the data, on already existing documentation of market participants and their willingness to cooperate with information. For parts of the indicators it can be necessary to estimate on base of experiences of operation, specifically if in the ecological and social areas verification is not legally required. In these cases it is important to compare the data to literature and experiences of other market participants to confirm the results.

4.8. Selection of the participants of the interviews

For selecting the participants the following scheme can be applied:

- Development of a list of existing plant operators in the region to be analyzed.
- Generation of criteria to select and eliminate for the interviews.
  - Elected should be plants that have potential to work as demonstration for future plant operators and whose market actions are influencing regional market participants.
  - 100 kW can be considered as minimal size of a plant. Smaller plants can be considered in a group of buyers of raw material.
  - Heating plants based on wood in wood processing enterprises are not considered because of the different base for decision on basis of existing raw material in comparison to other plants where input material has to be bought.
- Consultancy of willingness to cooperate at the elected plants.
- Elaboration and adaptation of the questionnaire in dependence of the participants to be interviewed.

This analysis considers an area that can concern internal data. Therefore, the main part of the interviews has to be taken personally due to the low willingness to facilitate company data by telephone. The requirement of non-publication of company data has to be acceded.

4.9. Interrogation of regional market participants in the research area

The interrogation of the market participants and plant operators can be executed by interviews supported by questionnaires. During the development of this methodology an excel-document was developed that allows the entering of the achieved data and contains different areas for potential allocation, planning, construction of the plant, conditioning, operation and product acceptance. Other parts can be added if necessary. A main emphasis is to be laid on the operation of the plant and therefore needed investment (level 1). As far as possible levels 2 and 3 concerning the potential allocation and product acceptance can be included in the module. The developed model allows the calculation and graphic demonstration of results. The areas: input–output, basis data, economy, social and ecology are demonstrated separately. For agricultural bioenergy project a data base for the calculation of energy crops and alternatively grown crops including their transportation costs and costs for their field application can be included. A special table for entering the required data facilitates the work with the module.

Tables 4–9 show the forms to enter the required input–output data for the analysis and its regional effects on the example of a biogas plant.

Table 4
Input field for input/output data [7].

Plant input	Amount of input	Unit	Costs of supply/t
Corn silage		tFM/a	
Grass silage		tFM/a	
Organic production rests		tFM/a	
Dry chicken litter		tFM/a	
Cow dung		tFM/a	
Pork manure		m^3 FM/a	
Cattle manure		m^3 FM/a	
Used area		_	ha
There from own area		_	ha
There from external owned area		_	ha
Total farm area for production			ha

Table 5
Input field for basis data [7].

Parameter	Zero-option	Biogas plant
Investment costs in €		
Regional part of invest in %		
National part of invest in %		
External capital in %		
Credit period in years		
Interest for external capital in %		
Income mineral oil seller/a		
Regional obtained services for maintenance and operation of energy generation/a		
Regional spending of participating farmers/a (2. level) from revenues of plant production		
Delivery costs for energy crops from external production in €/ha		
Electricity transfer to the grid in % of production		
Electrical efficiency CHP in %		
Assimilated credit in €		
Subsidy in €		
Revenues for waste disposal in €/a		
Combustible costs in €/a		
Used heat (without heating for fermenter) in kWh/a		
Costs in ct./kWh heat		
Revenues in ct./kWh electricity		
Average alternative costs for electricity supply for regional market participants from external market participants in €/kWh		
Average alternative heat supply costs for regional market participants from external market participants in €/kWh		

Table 6
Input field for economic data [7].

Economic value factors	Zero-option	Biogas plant
Installed electric capacity	kW_{el}	kW_{el}
Yearly full load hours	h	h
Amount of input of mineral oil/a	l	l
Factor of productivity of plant for electricity or heat production	%	%
Percentage of regional input amount	%	%
Reg. costs for processing and preparation of input/a	€	€
Alternative revenues for the raw material produced on own areas/a	€	
Max. transportation distance	km	km
Effective amount of material to be deposited/ha	m^3/ha	m^3/ha
Costs per m^3 substrate for depositing as internal activity (with own machinery)	€/m^3	€/m^3

Table 7
Input field for social data (1) [7].

Zero-option	Costs in €/h	Persona costs in €	Affected regional people in the area	High qualified in hours	Expert in hours	Low qualified/ apprentice in hours
				35	20	10
Paid personal costs once	Reg. planning					
	Reg. assembly of technology					
	Reg. construction of technology					
Not paid personal hours before operation	Internal labour for assembly and planning					
Paid yearly personal costs	Reg. raw material provision					
	Reg. Processing of energy container					
	Reg. operation of plant					
	Utilization of products					
Not paid yearly hours	Publication					

Table 8
Input field for social data (2) [7].

	Zero-option	Biogas plant
Amount of capacitated persons	People	People
Amount of people participating in the project	People	People
Amount of visitors hours per year	Hours	Hours
Amount of implemented projects after visits (not exclusive and as far as known)	Projects	Projects
Integration of existing networks		
Role of plant for future projects		

Table 9
Input field for ecologic data [7].

Sealed area needed	ha
Additional area covered with plants all year	ha
Reduction potential of nitrate leaching	%
Change of biodiversity and risk for building of monocultures	%

The generated data received from the input in these tables enter the module for the generation of value factors which are used themselves to build the indicators. The existing tool therefore can be used as a base for the examination of regional data to document the results and the production of regional added value. Different plants and value chains can therefore be compared.

4.10. Analysis of the consequences of different value chains

In demonstrating the results it has to be considered that endogenous potentials can be used in a region in different forms. The grand differences between the various biomasses require the use of different technology and enable the utilization of biomasses in different quantities and qualities, which influence transportation distances and requirement for handling (conditioning). Therefore, results generated in the value chains will also have different consequences in dependence of the form of technology implementation. The methodology can therefore also be used to define the most effective way to use a potential for regional value generation.

4.11. Evaluation of the results

The evaluation of the results is basing on the indicators that enable comparing different projects (different bioenergy plants with the "zero-option" and conventional plants). By simulation of different regional scenarios, the results on the regional added value can be documented and the regional effects of further implementation of regional resources can be demonstrated. Applicability of the results on other regions can be discussed. Based on the analyzed results possible results of future plants to be implemented can be simulated. Based on this, recommendations for future regional policy can be made to support regional development by using endogenous recourses.

5. Examples for utilizing the developed methodology

The developed methodology can be utilized in different ways. It allows on one hand to compare different existing technologies in terms of their regional effects. It can therefore be helpful for regional decision makers to analyze existing plants concerning their generated effects and guide future development. On the other hand the methodology helps political and strategic decision makers to direct their limited financial recourses to projects with the highest regional effect or to generate political support for projects that might be otherwise discussed widely. Fig. 4 compares the different yearly regional income generated by using regional

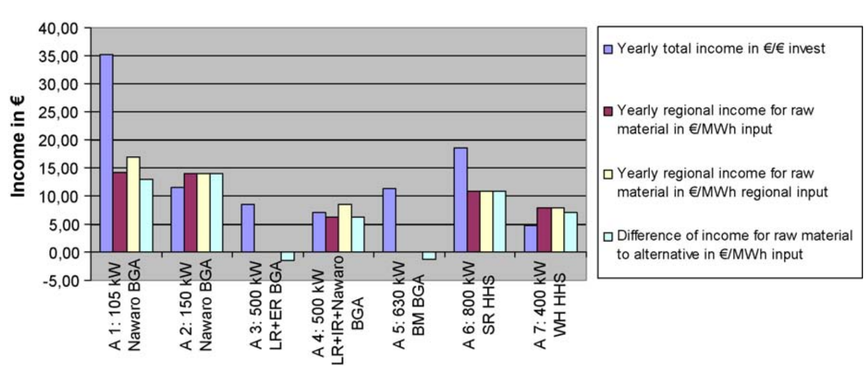

Fig. 4. Comparison of different admissions per MWh yearly input and € invest with the alternative [7].

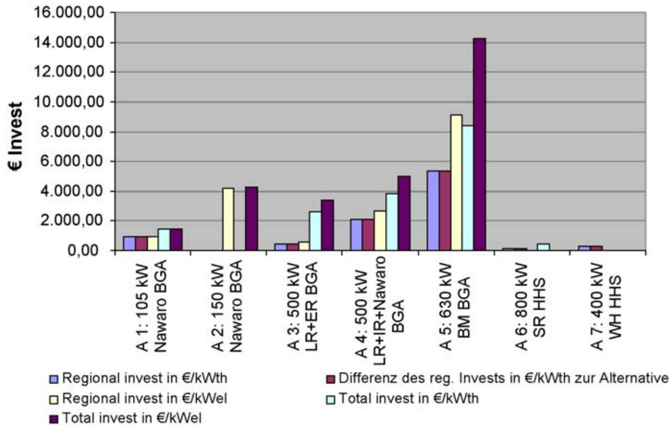

Fig. 5. Comparison of investment cost per kW thermal and electric as well as to respective alternative [7].

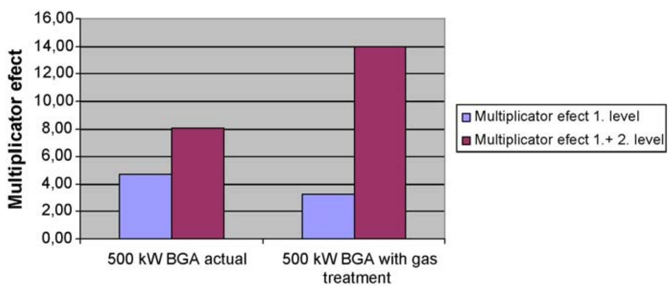

Fig. 6. Comparison of regional income by plant 4 before and after the installation of a gas treatment system [7].

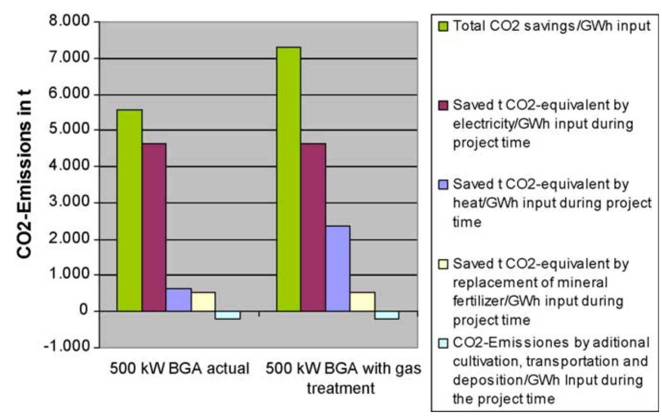

Fig. 7. Comparison of saved CO_2-emissions of plant 4 before and after installation of gas treatment [7].

bioenergy potentials (in MWh) in bioenergy plants and also compares them to alternative utilization.

In comparison to that Fig. 5 demonstrates the required total and regional investment per unit installed capacity for the different technologies and compares them to the alternative without project or with fossil energy.

The given example shows therefore that alternative A5 (a biogas plant on base of organic residues) has the highest effect on regional investment required for operating the plant, while plant A1 and A2 (both small biogas plants of 105 and 150 kW_{el} using agricultural input material) have the highest effect concerning yearly regional income per unit regional produced material. This comparison also shows that the two wood chip heating plants A6 (operated with uncontaminated waste wood) and A7 (operated with rest wood from the forest) that require low regional investment are providing a comparably high amount of yearly income per unit regional input material.

The comparison can also be extended to the ecologic and social area. Expected future development can be simulated, e.g. in the case of Fig. 6, where a biogas plant operator is considering to implement a gas treatment system to his existing 500 kW_{el} plant for feeding the gas into the natural gas grid. This would allow him to use the heat generated by the generator more efficiently but requires also further technology and a high investment as well as permissions depending on political decisions.

In this case regional income, not only on the first but also on the second level of the value chain (Fig. 6) as well as emission reduction (Fig. 7) or the generation of new jobs can make a difference.

6. Conclusions

The above-described methodology to compare and analyze regional added values gives a tool to clarify the real impact of regional bioenergy projects and enables the demonstration of more than only the economic facts and results of a project. Therefore, it gives local, regional and national stakeholders a broader base for strategic decisions concerning a sustainable development of the analyzed region. The tool can be applied on local and regional level for different investment decisions.

Acknowledgements

This paper is based on my work at the IfaS-Institute in different bioenergy projects where the term of regional added value kept coming up frequently without being defined clearly. I am grateful for the discussion and the constant input of Prof. Dr. Peter Heck who activated the idea for developing my doctoral thesis, giving an approach of a solution in this area. I would like to thank the colleagues of the Institute, project partners and plant operators taking part in many discussions and the German federal ministry of environment and nuclear safety for financing the study.

References

[1] Kaiser B. Werttheorie und Bewertungstheorie als Grundlage der Waldbewertung. Schriften aus dem Institut für Forstökonomie der Universität Freiburg, Band 2, Freiburg; 2001. p. 16
[2] Nicklisch H, Editor. Handwörterbuch der Betriebswirtschaft. Stuttgart; 1939. p. 71.
[3] Seischab H, Schwantag K, editors. Handwörterbuch der Betriebswirtschaft. Dritte völlig neu bearbeitete Auflage, Stuttgart; 1960. col. 6313.
[4] http://www.md-ecz.de/GP_Bew/glossar/wertschoepfung.html (19.7.06).
[5] Heck P. Regionale Wertschöpfung als Zielvorgabe einer dauerhaft, nachhaltigen, effizienten Wirtschaftsförderung; 2004, p. 7. In: Forum für angewandtes systemisches Stoffstrommanagement, 2. Jahrgang; 2004. p. 5–12.
[6] Forum für angewandtes systemisches Stoffstrommanagement (FasS). Institut für angewandtes Stoffstrommanagement, Birkenfeld.
[7] Hoffmann D. Regionale Wertschöpfung durch optimierte Nutzung endogener Bioenergiepotenziale als strategischer Beitrag zur nachhaltigen Regionalentwicklung (Dissertation), Saarbrücken; 2007 (http://scidok.sulb.uni-saarland.de/volltexte/2007/1156/index.html).
[8] Großklos M. Kumulierter Energieaufwand verschiedener Energieträger und -versorgungen. Results calculated with GEMIS Version 4.13, Institut für Wohnen und Umwelt Darmstadt (IWU). Darmstadt; 2002.
[9] Heck P, Hoffmann D, Wern B. Studie zur Weiterentwicklung der energetischen Verwertung von Biomasse in Rheinland-Pfalz. On behalf of the ministry for environment and forestry of the federal state of Rhineland Palatinate. Mainz; 2004.

Dr. Dunja Hoffmann is presently renewable energy advisor for the German agency for technical cooperation (gtz) in Eschborn in the competence centre Energy and Transportation, after being sent as an integrated expert of the Centre for International Migration and development (CIM) to the Chilenian Pontificia Universidad Católica de Valparaíso where she had a post-doctorate position for the development of bioenergy projects as well as for academic activities in renewable energies and material flow management. She worked in her first bioenergy projects during her undergraduate thesis as environmental economist at the University of Applied Sciences Trier, Environmental Campus Birkenfeld, in the European "Local sustainable development project" (LSDN) and afterwards in various national and international bioenergy projects at the Institute for applied material flow management (IfaS). While researching for her doctoral thesis in geography she worked in the "Bioregio project" for the German federal ministry of environment and focused her work on regional added value.